scratch or bite. They are very fond of caresses, and will lie quite still to receive them, crooning a little in a ridiculously satisfied way. I knew a tame Ateles of another species which always met one with an embrace around the neck; this was not an acquired trick, but simply the natural expression of its affection for human beings.

One individual of a large *Cebus* was brought in; it was a great rarity, and none of our hunters recognized it at all. There is a smaller monkey occasionally seen here, which I judge to be also a Cebus, but we did not obtain specimens. The marmosets do not seem to be represented, at least in the eastern part of this province.

Bats were rather common, but by no means as numerous as in equatorial Brazil, and none of the species which we obtained were very large. So far as I could discover, the blood-sucking kinds are unknown here.

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THE EXHALATION OF OZONE BY FLOWERING PLANTS.

BY J. M. ANDERS, M.D., PH.D.

(Continued from page 344.)

IT became evident that in order that this important question might be set at rest, the conditions would have to be varied and further observations instituted. I now set to work to devise the necessary apparatus to carry on such experiments. Accordingly I had made a glass case large enough to contain a dozen or more thrifty growing plants in pots. Its dimensions were as follows: length, three and a half feet; width, two and a half feet, and height, two and a half feet. A portion of the top was left removable, so as to furnish an aperture through which the plants could be placed in the case and again taken out. Such an arrangement as this would admit the sunlight to the plants and confine their exhalations, and thus give the ozone, if any should be generated, a better opportunity of acting upon the test papers. In all of the remaining experiments here recorded I was greatly assisted by Mr. G. B. M. Miller, my medical student. The apparatus was first placed in the bay window of an occupied sitting-room facing east. The plants here received the sun's rays for at least six hours of the day. A dozen thrifty plants were placed in the

case, which was then accurately closed by the removable piece of glass already spoken of; the test papers having been moistened and tacked on the branches or stems of the plants. In the first series of experiments flowering plants were used, twelve in number, each having several flowers and about four square feet of leaf surface. They consisted of varieties of geraniums, fuchias, begonias, hydrangeas and petunias. Upon these plants eighteen observations were made of about four hours each, during the latter part of the month of May, 1883; weather mostly fair. The Schoenbein showed "very slight" indications for seven of the experiments and one "slight" coloration, there being ten negative results. The guaiacum papers gave more striking results, the change in the papers being marked for ten of the experiments and slight for the remaining trials, save one which was negative. Great care was taken to keep the plants experimented with in a healthy condition; they were also left in the pots in which they had been grown. There are two reasons which can be assigned why the results in these experiments were not very striking with the iodized starch test First, the experiments were of too short duration; and secondly they were conducted indoors, for the air of the case was originally the air of the room, and a portion at least of the ozone which might have been generated by the plants would have been decomposed by the impurities of the air in the case.

With a full knowledge of the very unfavorable conditions under which these experiments were conducted, but encouraged by their moderate success, it was resolved to make a trial of odoriferous flowering plants under the same conditions. Again our little floral chamber was filled with plants, consisting of seven rose bushes, four carnation pinks, and six heliotropes. The duration of observations about ten diurnal hours each; weather mostly clear, two days cloudy. With the Schoenbein test there were "very slight" reactions in most instances, two "slight" and one well "marked," while the guaiacum papers were "marked" in most cases, a couple being "slight." The number of experiments were eight. These investigations suggested the idea naturally that odorous flowering plants might be better ozone generators than inodorous ones. The external atmospheric conditions were very similar during the time of both the preceding sets of experiments, the maximum temperature ranging

from 85 to 88° Fahr. Repeated testing of the atmosphere of the room in which the case was situated gave no indications of the presence of ozone.

The question now very naturally arose whether the colorations were due to ozone or to some of the substances which give the same reactions with these papers; hence, further investigation was necessary in order to exclude, if possible, these interfering conditions, before it could be claimed for plants that they were capable of emitting or converting the oxygen of the air into ozone. It was also deemed important to conduct future experiments out of doors as, for reasons already given, it was expected more decided results would be obtained. The case was removed to the back yard, which lies to the eastward of the dwelling. Here the plants received the sunlight for at least eight hours daily during clear weather, and the yard was of good size. In the first series of experiments in this locality the plants last named were employed.

After observations for seven consecutive days of clear weather the Schoenbein paper gave "slight" reactions in four cases and "marked" reactions in three. The guaiacum paper gave "slight" indications in three and "marked" in four experiments. It will be seen that these experiments gave more marked results than those made within doors. It may be stated that it was found that the coloration of the Schoenbein or iodized starch test was "slight" instead of "very slight" as indoors, and in three cases actually "marked," against one "marked" result in the preceding series. The guaiacum tests were nearly correspondingly more marked. It is probable that the more surprising results of the last series are not attributable solely to the change of location, but also in some degree to the fact that the experiments were of longer duration. A piece of red litmus suspended in the case during these experiments gave no indication of the presence of ammonia. Peroxides of hydrogen could not have been the reactionary agent, since that substance is decomposed at a temperature of 70° Fahr., while the temperature of the atmosphere within the case, which was carefully noted, was never found below 90° Fahr. These observations were made during the first week in June, 1883, the weather being very warm and the temperature of the air within the case being higher than that of the external air. Good reactions were, however, obtained in later experiments,

when the temperature did not mark over 70° Fahr. That the reactions were not due to the nitrous oxides, perhaps the only remaining substances capable of producing like colorations of these test papers, will appear evident hereafter.

It was next proposed to give foliage plants having soft thin leaves a trial. Seven asperdisteus, one fern and three dracænas were chosen for experimentation. These observations were conducted during the first week in September, 1883, for seven consecutive days. The weather was extremely warm, the temperature of the air within the case ranging from 85 to 100° Fahr., the sky was clear during four days and partly cloudy the remaining three. The Schoenbein test paper gave negative results throughout, while the guaiacum gave one "very slight" reaction, the rest being negative also. Thus it would appear that foliage plants have not this power of generating ozone, the function must therefore reside with the flower, but of its nature we shall speak hereafter.

As our first experiments with inodorous flowering plants did not yield results striking enough to afford a basis for positive conclusions, it was considered desirable to apply the tests to them in the open air, which was done. Seventeen thrifty geraniums were employed. The temperature was lower during these experiments than during those made indoors with inodorous plants. For six consecutive days, experiments being of ten hours each duration, the Schoenbein gave one negative, two "slight" and three "marked" blue shades. The negative result occurred upon a rainy day, during which there was no sunshine whatever. This would indicate that sunlight, or at least good diffused light, is essential to the generation of ozone by plants, for the plants were protected from the rain by the glass. There are other physiological processes carried on by plants which are almost entirely dependent upon the power of the sun's rays, *e. g.*, assimilation and transpiration. To the above may doubtless be added the development of ozone.

Observations were continued upon these plants during the second week of September, the result being about similar to those last noted, the Schoenbein gave two "marked," one negative, on a rainy day, and the rest "slight" reactions. The guaiacum papers gave two "striking" and the rest "slight" colorations. As already intimated nitrous oxides, which are present in the air,

change the color of these test papers very much as ozone does. To exclude the possibility of the change in color being due to the nitrous oxides, we tested the air during the latter set of experiments on the outside of the case simultaneously, and found that the papers in this situation gave only one "slight" reaction, and even though this occasional reaction on the exterior had been due to the presence of the nitrous oxides, they could not have caused the much more striking and constant tests obtained on the inside. Again, it is not at all likely that the plants generated nitrous oxides, which in turn might have changed the test papers, for there is nothing in all vegetable physiology to support such an hypothesis. Moreover, it is all the more improbable that nitrous oxides caused the blue colorations, since they did not do so *when foliage plants were employed.*

We do not wish to say dogmatically that all the changes in the test papers were due to ozone, but from the many beautiful reactions obtained, and the systematic precautions taken to preclude the action of other substances known to answer to like tests, it will not be denied that the chief agent in changing the papers was ozone. I was unable to detect the odor of ozone upon which Professor Leeds lays so much stress, but Mr. Miller thought he could detect its presence. It must be borne in mind that the amount of plant life within the case was probably too small to generate sufficient ozone to make it perceptible to the sense of smell.

It would appear certain from these experiments, that the leaves which are so actively engaged in carrying on the important functions, as, for example, transpiration, have nothing whatever to do with the production of ozone. But, on the other hand, it is to the flower that is delegated this highly important, though perhaps hitherto unthought of, function in plant life.

Can we, from the facts derived from these observations, come to any definite conclusions respecting the nature of this function? Is the cause to be sought in the functions of the petals or in the formation of the seed? Let us here recall how ozone can be produced artificially, and it will be remembered that one mode is by suspending phosphorus in moist air. Now it is known that the ashes of seeds contains large quantities of the phosphates. It follows that during the formation of the seeds there is a rapid metastasis of phosphorites in the form of phosphoric acid and

the phosphates to that organ of the plant, and it may reasonably be supposed that in the chemico-vital changes going on in the ovules, phosphorus is liberated and acted upon by the moisture which the leaves and petals are so actively transpiring.

As corroborating this view we may allude to the phenomena of phosphorescence in plants as observed by M. Crié and others. In a communication to the French Academy, M. Crié states: "It is well known that the flowers of phanerogams are capable, under certain circumstances, of producing phosphorescent light. The phenomenon has been verified, especially of the nasturtiums and the marigold. Some years ago I myself saw phosphorescent light emitted in stormy weather from the flowers of the *Tropeolum majus* cultivated in a garden." Although an absolute decision may not be possible, the above facts, when taken together, are suggestive of the correctness of this explanation. The subject, however, merits further investigation.

In the light of the present experiments there can scarce be a doubt but that a manifest relation does exist between vegetation and the ozonic condition of the atmosphere. And this, it will be conceded, is not the least hygienic influence possessed by plants. During fair weather all flowering vegetation in nature is contributing ozone to the atmosphere. In this connection it should be borne in mind that vegetation is largely blooming, that numerous field plants, the forest trees, as well as all fruit trees put forth flowers, and that during this period they all add their quota of ozone to the surrounding medium. Again, not all blooming plants or trees produce their flowers at the same time of the season, so that it happens that there are a certain proportion of different species flowering in turn from early spring till late in autumn, and hence the effect upon the atmosphere with reference to the amount of ozone they give to it must be pretty constant during the whole vegetative period wherever vegetation abounds. We here have another evidence of the fact that in His eternal wisdom the Author of nature has intrusted to plant life the task of maintaining the harmonious composition of the atmosphere. A certain proportion of ozone in the atmosphere is essential to prevent it from becoming too much polluted for animal respiration by the products of decomposition, particularly of azotized substances, which are known to be a fruitful cause of disease, and which are believed by some to serve as carriers for the germs of epidemic and contagious diseases.

Upon this point Professor Kedzie observes: "I call ozone the most energetic of the constituents of the atmosphere. Its presence or absence must have a *controlling influence over the vital powers.* And when we consider that this material is present in such variable amount in a medium which enfolds us every moment of our lives, and where action 'pauses not for matin or for vesper, at noon of day or noon of night,' it seems to me that no one can deny that its influence on human health must be most significant."

Professor Max von Pettenkofer says of the hygienic value of ozone in the air: "It is the constant purifier of the atmosphere from all organic matter which passes into it and might accumulate. The air would have been long ago filled with the vapors of decomposition if it were not for ozone, which oxydizes all that is oxydizable, if only time be allowed for it and too much is not expected at once."[1]

How long it would be possible for animal life to exist were all the atmospheric ozone to be suddenly annihilated, cannot be computed; but that existence would sooner or later become impossible on account of noxious substances which would accumulate in the air, and which it is the office of the ozone to destroy, cannot be reasonably doubted. How infinitely wise and beneficent, then, is the Author of nature in placing beside these destroying elements the means of reparation. And as flowering plants serve as natural ozone generators, they must be looked upon as worthy of being placed in the front rank as hygienic agents.

Perhaps the most interesting phase of this question is the application of the results of our observations to the beneficial effects of the cultivation of plants in dwellings. As already incidentally mentioned, ozone is not detectable in living rooms for the reason that it is decomposed in oxydizing the organic matter present. It was also seen that flowering plants generate ozone indoors during clear weather, and if a dozen thrifty plants, in a case of the dimensions of the one employed, give us a reaction, then it will not be doubted that a living room well stocked with flowering plants would give off sufficient to be of hygienic value, since it is well known that we rarely or never find but a small quantity in the external air, which yet serves to maintain it in a salubrious condition. The air of dwellings is very generally charged with

[1] *Popular Scicnce Monthly*, Feb., 1878.

deleterious substances due to human respiration, insufficient ventilation, the presence of sewer gases, and many other causes. That the hygienic conditions of the air of living rooms is almost universally abominable is admitted by the best authorities, and it is also true that this bad air of our dwellings serves admirably as a culture fluid for the various disease-producing germs. How to obviate the ill effects arising from this unfortunate condition of things is a question of paramount importance. Since plants are capable of generating ozone, which has the power of destroying not only the organic impurities but even disease germs, it follows that the requisite amount of flowering plants grown in our living rooms would, in a great measure, rid the air of these deleterious substances. From these observations it will readily be conceded that the value of house-plants as hygienic agents can scarcely be overrated. That no possible objection can be urged against the practice of keeping blooming plants in our living rooms (excepting in the case of those having pronounced odors, as the tuberose, etc.) has been shown conclusively elsewhere, and the old time prejudice, we are happy to be able to state, is rapidly dying out.

Shall we discard the foliage varieties because they are incapable of producing ozone? By no means; there are also important advantages to be derived from their presence. Not to speak of their æsthetic influence, there is, as already pointed out, confided to the leaf the important function of transpiration or exhalation of watery vapor. This process is carried on so actively by leafy plants as to give them the power to raise the degree of humidity of a closed apartment which is usually far below the health standard, as the writer has shown in previous articles.[1] It simply remains to be said that, in view of these experiments, the flowering treasures of the green-house as well as foliage plants should be welcomed into every household as being among our noblest sanitary agents.

[1] "Transpiration of Plants," AMER. NAT. for March, 1879; also "Beneficent Influence of House Plants," AMER. NAT. for Dec., 1879; also "Hygienic and Therapeutic Relations of House Plants," *Phila. Med. Times* for May 8, 1880.